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FRIEND-FOE DISCRIMINATION, CAFFEINE, AND SENTRY DUTY

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In war, the sentry must continually and rapidly detect targets, correctly discriminate friend from foe, and shoot with accuracy. Past research shows that caffeine enhances the sentry's target detection speed when all targets are foes. This study evaluates sentry performance when friend-foe discrimination is required. Eleven men and 11 women participated in four simulated sentry duty sessions lasting 3 hours each: (a) 200 mg caffeine, foe-only; (b) 200 mg caffeine, friend-foe; (c) placebo, foe-only; and (d) placebo, friend-foe. Participants monitored the target scene of the Weaponeer Rifle Marksmanship Simulator with instructions to fire at enemy targets. Without impairing marksmanship, 200 mg caffeine reduced friend-foe discrimination errors and eliminated the decrement in target detection speed associated with time on the task. Men were likely to commit friendly-fire errors (shoot at friendly targets) and women were likely to commit fail-to-fire errors (fail to shoot at enemy targets).

INTRODUCTION

On the battlefield, it is imperative that soldiers be able to discriminate friend from foe. Research from the Persian Gulf War has shown that of the 219 (212 men and 7 women) U.S. casualties, 154 were killed in battle; thirty-five, or 22.7 percent, of these battle deaths were the result of friendly fire (Helmkamp, 1994). Data from all 20th century conflicts demonstrate a consistent fratricide rate of at least 10-15 percent, and it has been argued that correct target identification is impaired by combat stress, including time on duty without relief (Steinweg, 1994). The job of the combat sentry is particularly difficult. During extended, and often boring, periods of time the sentry must remain vigilant for the appearance of targets, correctly discriminate friends from enemies, and fire accurately (and only) at enemy targets. In order to study sentry duty performance objectively, we have adapted the Weaponeer Rifle Marksmanship Simulator, a training device, for use in the laboratory.

The U.S. Army uses the Weaponeer in its basic rifle marksmanship training courses. The Weaponeer utilizes a modified M16 rifle, simulates realistic recoil, and presents a variety of both stationary and pop-up targets (Spartanics, 1985). The Weaponeer measures both the speed component (accuracy in hitting rapidly appearing pop-up targets) and the variability component (accuracy in terms of the tightness of the shot group) of M16 rifle firing. Soldier performance on the Weaponeer is predictive of live fire performance (Schendel, Heller, Finley, and Hawley, 1985). The Weaponeer has been used in the laboratory for the assessment of soldier performance under varying environmental extremes (heat, cold,

chemical contamination) and scenarios including simulated sentry duty (Johnson, 1991; Johnson and Kobrick, 1988; Johnson and McMenemy, 1989; Johnson, McMenemy, and Dauphinee, 1990).

In our original sentry duty study (Johnson & McMenemy, 1989), the rifle marksmanship of 8 male soldiers was assessed with the Weaponeer during 3 hours of simulated sentry duty. The participant had to respond to the infrequent appearance of an enemy target at a simulated distance of 250 meters (12 presentations per 30 minute period). When the target appeared, the soldier's task was to pick up the rifle, aim, and fire at the target. Target detection latency increased with time on sentry duty such that impairments were clearly evident after 60 minutes. Rifle firing accuracy, or the ability to hit the targets, remained constant over time; soldiers were just as accurate at the end of 3 hours of sentry duty as they were at the beginning of the session. Using the same paradigm, we studied the effects of caffeine (an over-the-counter stimulant commonly used to maintain mental alertness) on sentry duty performance of 12 male soldiers (Johnson, 1991). The results showed that 200 mg caffeine (equivalent to about 2 cups of coffee) markedly improved the sentry's speed of target detection and M16 rifle firing accuracy was left unimpaired. The efficacy of 200 mg caffeine in alleviating performance decrements in the sentry duty situation was replicated with female soldiers (Johnson & Merullo, 1996).

From our first three studies, we concluded that during sentry duty (a) target detection speed and M16 rifle firing accuracy may be enhanced if sentry duty is limited to one hour; and (b) without compromising rifle firing accuracy, target detection speed may be enhanced by a 200 mg dose

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of caffeine. While these results are consistent with what is generally accepted about caffeine being a mild stimulant and about time on a task leading to impaired vigilance performance, their generalizability to the U.S. soldier may be limited. That is, these studies were conducted with all targets being foe (meaning that the sentry fires at any and all targets). This is of vital importance since soldiers on the battlefield must routinely discriminate friend from foe and wartime fratricide rates indicate that friend-foe discrimination decisions are not always correct.

The purpose of this study was: (a) to evaluate speed of target detection, frequency of correct target identification (friend vs. foe) and accuracy of rifle firing during three hours of simulated sentry duty; and (b) to determine if 200 mg caffeine enhances sentry duty performance in a friend-foe scenario as it has been shown to do in foe-only scenarios.

METHOD

The study design was modeled on a 2 (gender) x 2 (drug) x 2 (target scenario) x 6 (time period) factorial experiment with repeated measures on the last 3 factors. Using a double-blind procedure, male and female test participants received either a 200 mg caffeine tablet or a placebo tablet 10 minutes prior to performing six consecutive half-hour segments of simulated sentry duty. In the foe-only condition, targets were always unfriendly and were always to be fired upon. In the friend-foe condition, one-half of the targets were friendly (not to be fired upon) and one-half were enemy (to be fired upon).

Twenty-two soldier volunteers (11 men and 11 women), were recruited from the military test participant population at the U.S. Army Natick Research, Development and Engineering Center (Natick, MA). They were screened to eliminate anyone with medical conditions which might be aggravated by the administration of caffeine. Only those prospective test participants with acceptable vision (20/20 Snellen correctable) were allowed to participate. During all training and test sessions, participants were dressed in the standard U.S. Army battle dress uniform (including helmet, armor vest, web belt, and full canteen).

Prior to testing, participants were given rifle marksmanship training on the Weaponeer M16A2 Rifle Marksmanship Simulator and were familiarized with the targets to be presented during testing (full body E-type silhouettes at a simulated distance of 300 meters). Using a double-blind Latin square design, participants were then exposed to four separate test conditions over four separate test days: (a) 200 mg caffeine, foe-only; (b) 200 mg caffeine, friend-foe; (c) placebo, foe-only; and (d) placebo,

friend-foe. Test days were separated by days off to eliminate possible confounding due to residual drug effects.

Testing was conducted in the morning between 0800 and 1200 hours. Participants were not permitted to consume caffeine for 12 hours prior to a test day or alcohol for 24 hours prior to a test day, and were instructed to be in bed by 2200 hours the night before a test day. The test session lasted three hours, during which time the participant assumed a standing foxhole position and monitored the target scene of the Weaponeer. The Weaponeer M16A2 modified rifle lay next to the participant at chest height. When a pop-up target appeared, the participant pressed a telegraph key, lifted the rifle, aimed, and fired at the target. The number of stimulus (target) presentations per 30 minute period was 12, with interstimulus intervals of .75, .75, 1, 1, 1, 1.5, 2, 2, 2, 3, 5, and 10 minutes. These interstimulus intervals were randomized for each 30 minute period. Each target was set to appear for 6 seconds. The Weaponeer was set in the "kill" mode, providing the participant with immediate feedback as to whether or not the target was hit; that is, if the target was hit it would fall; if the target was missed, it would remain in view for the full six seconds before falling. The participant was instructed to respond with the telegraph key to all targets, but to fire only at enemy targets. Friendly targets were indicated by the illumination of a light adjacent to the target during the first second of the 6-second target presentation. In the foe-only condition, all targets were to be fired upon; in the friend-foe condition, one-half the targets were randomly presented as friendly. *Target detection time* was measured in terms of the time required by the participant to press the telegraph key in response to the appearance of the target. This time interval was measured by a Lafayette electronic stop clock started through a relay in common with the target presentation switch of the Weaponeer control console. Pressing of the telegraph key de-activated the stop clock. *Accuracy of friend-foe discrimination* was measured by summing the number of correct target identifications (number of fires at foe targets plus number of fire-holds when presented a friendly target) in response to the 12 targets for each 30 minute period. *Marksmanship* (rifle firing accuracy) was measured in terms of percentage of targets hit per 30 minute period. Target detection time, accuracy of friend-foe discrimination, and marksmanship were averaged every 30 minutes.

Target detection time and marksmanship were each analyzed by means of a 2 x 2 x 2 x 6 (gender x drug x target scenario x time period) analyses of variance with repeated measures on the last 3 factors. Accuracy of friend-foe discrimination was analyzed by means of a 2 x

2 x 6 (gender x drug x time period) analysis of variance with repeated measures on the last 2 factors.

RESULTS

Target Detection Time

A significant main effect of drug, $F(1,20) = 20.48$, ($p < .01$), showed that target detection time was significantly improved by 200 mg caffeine ($M = 1203$ milliseconds) compared to placebo ($M = 1437$ milliseconds). A significant drug x time period interaction, $F(5,100) = 6.02$ ($p < .01$), showed that for the control condition, detection time increased as time on sentry duty increased; for the caffeine condition, the increase in detection time was not significant. Lastly, there were no significant main effects for gender or for target scenario. These relationships are graphically illustrated in Figure 1, where male and female data are combined to show the drug x target scenario x time period effect.

Marksmanship

For marksmanship, there were significant main effects for gender, $F(1,20) = 6.04$ ($p < .05$), for drug, $F(1,20) =$

11.89 ($p < .01$), and for time period, $F(5,100) = 4.08$ ($p < .05$). Men ($M = 63.8\%$ hits) were more accurate than women ($M = 48.7\%$ hits); accuracy was better with caffeine ($M = 60.0\%$ hits) than without ($M = 52.4\%$ hits); and rifle firing accuracy became poorer with time (first 30-minutes: $M = 60.6\%$ hits; last 30-minutes: $M = 52.1\%$ hits). There was no significant main effect for target scenario and there were no significant interactions. These relationships are graphically illustrated in Figure 2 where target scenarios are combined to show the gender x drug x time period effect.

Accuracy of Friend-foe Discrimination

A significant main effect for drug, $F(1,20) = 8.15$ ($p < .01$), showed that friend-foe discrimination accuracy was somewhat better with caffeine ($M = 11.7$ correct) than with placebo ($M = 11.3$ correct). There were no significant main effects for gender or for time period. Categorization of discrimination errors into friendly fire errors (shooting a friendly target) and fail-to-fire errors (failure to fire at an enemy target) showed that the frequency of errors was the same for each gender (overall error rate = 4.3%), but that men were likely to commit friendly fire errors while women were likely to commit fail-to-fire errors. Figure 3 illustrates error rates for men

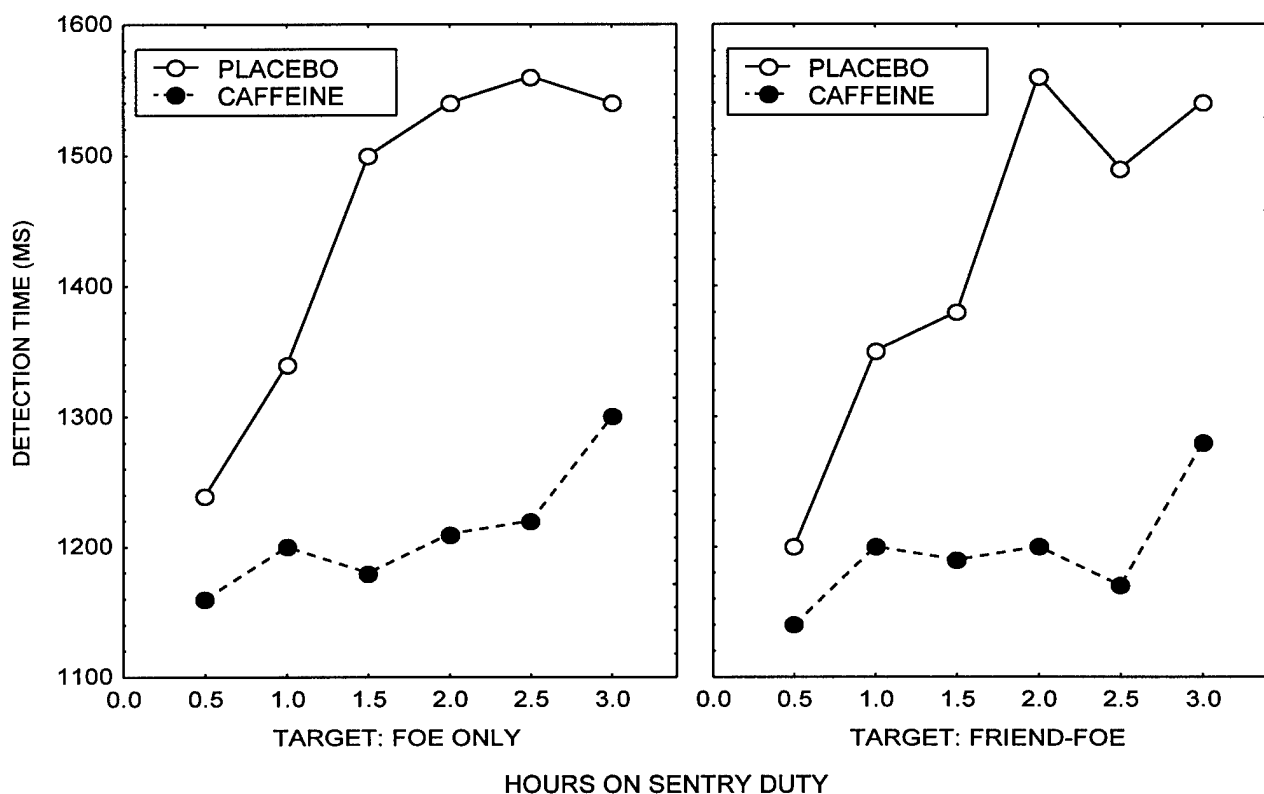


Figure 1. Target detection time: drug x target scenario x time.

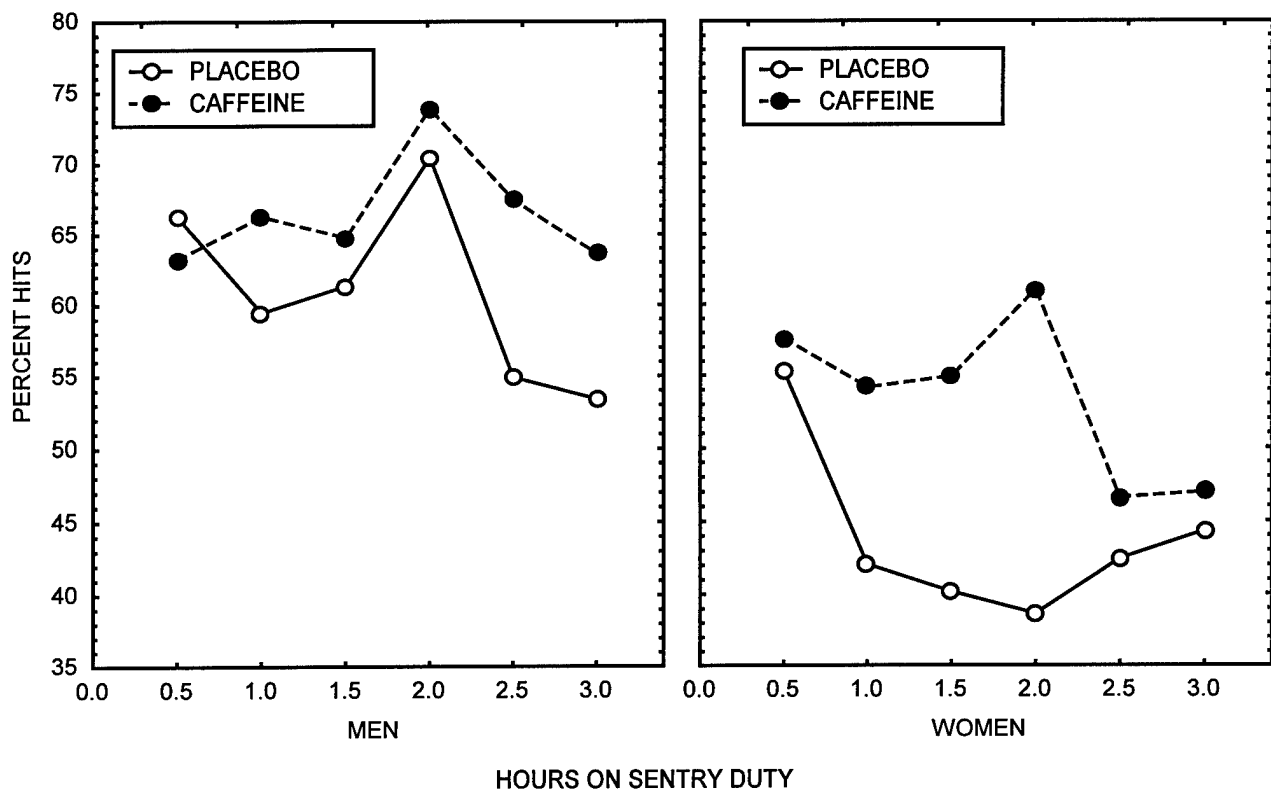


Figure 2. Percentage of targets hit: gender x drug x time.

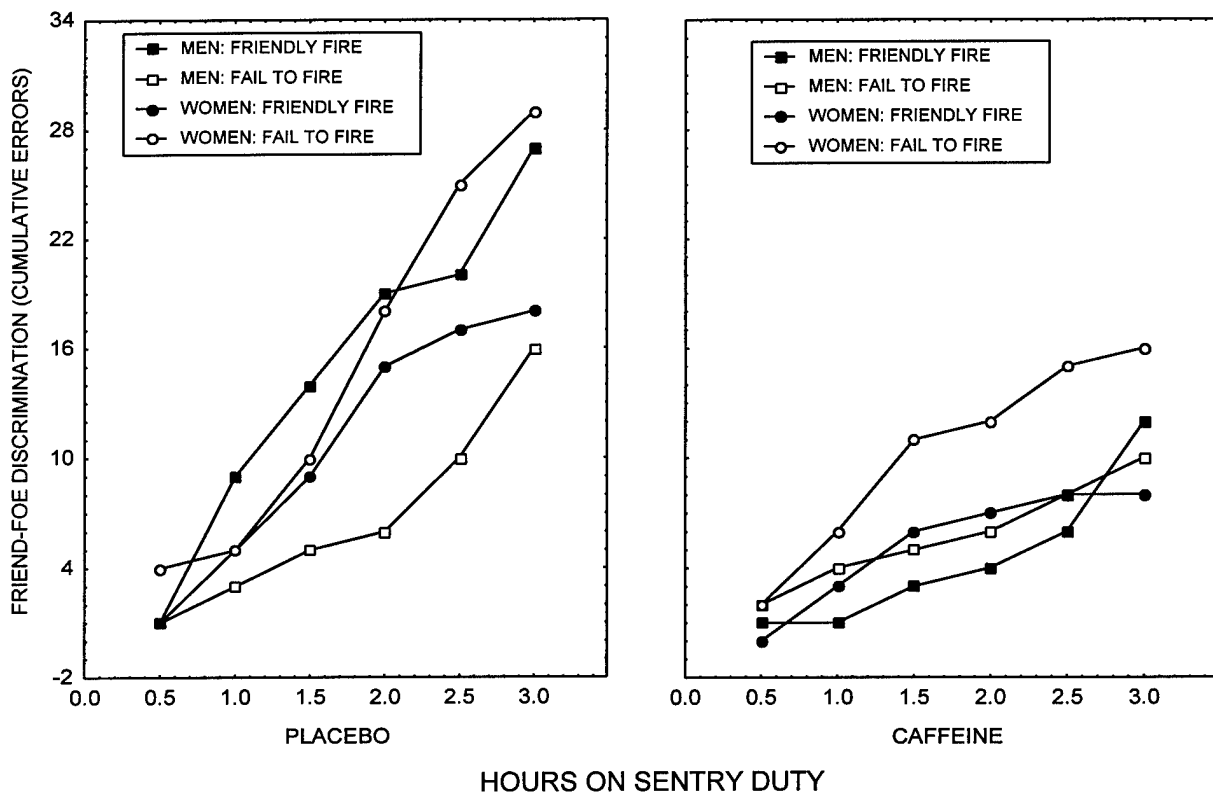


Figure 3. Categorization of friend-foe discrimination errors.

and women by error type over 3 hours sentry duty.

DISCUSSION

This study supports previous studies which have shown that, without impairing rifle firing accuracy, 200 mg caffeine attenuates or eliminates the vigilance decrement curve during three hours of simulated sentry duty, and that this relationship is the same for men and for women. In this study, 200 mg caffeine was actually shown to improve rifle firing accuracy for all participants.

While previous Weaponeer sentry duty studies have utilized a foe-only target scenario, where all targets are considered to be enemy and are to be fired at, this study introduced a requirement that participants discriminate friendly from enemy targets before shooting. The results show that 200 mg caffeine improves the accuracy of friend-foe target identifications, and that categories of friend-foe target discrimination errors (friendly fire and fail-to-fire errors) are equally reduced by 200 mg caffeine. Interestingly, men are likely to commit friendly fire errors, and women are likely to commit fail-to-fire errors.

CONCLUSION

Caffeine proved to be effective in improving sentry duty performance. Compared to control conditions, 200 mg caffeine significantly improved both speed of target detection and improved accuracy of friend-foe target identification for both men and women during 3 hours of simulated sentry duty.

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official documentation. Human participants participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

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